Proximity Effects and Spin-Orbit Phenomena with 2D materials

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The ability of graphene to be easily interfaced with different classes of magnetic (FM) materials (ferromagnets, magnetic insulators and semiconductors etc.) makes it extremely attractive for spintronics [1]. On one hand, magnetism can be induced within graphene by means of magnetic insulator proximity effect [2]. On another hand, spin-orbit phenomena including perpendicular magnetic anisotropy (PMA) and Dzyaloshinskii-Moriya interaction (DMI) at interfaces comprising ferromagnet with heavy metal [3] or oxide [4] played a major role in advent of spin-orbitronics [5]. Here we show that interfaces comprising FM two-dimensional (2D) materials (i.e. graphene, h-BN) combined with FM metal (i.e. Co) represent a viable alternative for advancing spintronics and spin-orbitronics applications. First, theoretical insights into physical mechanisms of enhancement of PMA and DMI in adjacent FM metal at Co/graphene and Co/h-BN interfaces [6,7,8] will be provided. Possibilities of controlling the DMI by graphene hydrogenation [9] and inducing skyrmion states at Co/h-BN interfaces [8] will be discussed. Next, recent developments on magnetic insulator proximity induced phenomena in graphene [2,10] including novel class of spin transport phenomena called proximity electro- (PER), magneto- (PMR), and multiferroic (PMER) resistance effects [11,12]. Finally, DMI mechanisms and possibility of inducing skyrmions in 2D magnetic materials are introduced [13,14]. Support from the European Union 7th Framework and Horizon 2020 Research and Innovation Programme "Graphene Flagship" under grant agreements 604391, 696656, 785219 and 881603 is acknowledged.

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